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Discard and gear escapement survival rates of some Northeast groundfish species

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by
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This Working Paper pertains to Term of Reference B (Commercial Discards) and consists of a summary of discard and gear escapement survival rates for some of the Northeast groundfish species (Tables 1 and 2). The primary factors that affect the survival of discarded fish include: fishing gear type and characteristics, fishing time, fishing depth, handling methods and time, fish species and size, volume and composition of the catch (for trawls), predation rates of injured individuals (particularly by seabirds), and environmental conditions (Suuronen 2005). Therefore, it is important that discard survival rate studies reflect commercial fishing conditions.

There are few discard survival rate studies involving Northeast groundfish species and many of the studies were conducted in waters other than those off the eastern U.S. coast (Tables 1 and 2). Survival rate estimates for a particular species can be quite variable between studies which utilize the same gear types and no confidence intervals were reported for these estimates. Based on the limited data available, discard survival rates for trawl-caught winter flounder and yellowtail flounder were highest for the eight groundfish species that were studied. Survival rates tend to be lower for species that have swim bladders (e.g., pollock, haddock, and cod) or other organs that inflate due to pressure changes following capture (Davis 2002). Discard mortality is size-dependent for trawl-caught haddock (Soldal et al. 1991; Sangster et al. 1996), cod (Robinson and Carr 1993; Carr et al. 1995), Atlantic halibut (Neilson et al. 1989), witch flounder (Ross and Hokenson 1997), and American plaice (Carr et al. 1995; Powles 1969). All of these studies showed that large fish had higher discard survival rates than small fish.

There are few discard survival rate studies involving static gear types. The longline discard survival studies that have been conducted indicate that discard mortality is largely dependent on the dehooking method and the ability of a species to quickly swim below the surface upon release so as to avoid avian predation. The “crucifier” method of dehooking which is commonly used in the Northeast longline fisheries is associated with fairly high rates of mortality for cod (Milliken et al. 1999), especially when post-release avian predation mortality is considered, and haddock (Huse and Soldal 2002). Longline discard mortality is size-dependent for cod (Milliken et al 1999) but not Atlantic halibut (Neilson et al. 1989). (Rudolph et al. 2006).

Increases in minimum codend mesh size and other gear selectivity measures implemented to reduce fishing mortality rates on immature fish is based on the assumption that escapees survive because they are not seriously injured. However, field and laboratory studies have shown that some of these escapees may die. Survival rates for escapees from trawl codends are generally species-specific and determined primarily by mesh size and shape, fish size, and other factors (Suuronen 2005). A report of the ICES Working Group on Fishing Technology and Fish Behaviour (ICES 2000) summarizes gear escape mortality and other sources of unaccounted fishing mortality. Both immediate and delayed mortality can occur because physical injuries can lead to disease and/or increased predation. Therefore, the survival monitoring period utilized in discard and gear escape mortality studies is an important consideration. Trawl escape mortality has been shown to reach a peak at two to three days after escape then declines to a minimum after one to two weeks (Suuronen 2005). Escape mortality studies must also ensure that the mortality is attributable to fishing gear escapement rather than experimentally-induced (Breen et al. 2002, ICES 2000). Atlantic cod and winter flounder (DeAlteris and Reifsteck 1993) as well as pollock (Ingolfsson et al. 2007) exhibit fairly low levels of escape mortality from trawl gears but escape mortality levels for haddock tend to be much higher (Soldal et al. 1991; Sangster et al 1996), particularly for fish less than 15 cm in length (Breen et al. 2007), which may be due to the poorer swimming ability of small individuals (Breen et al. 2004).

The inclusion of discard and codend escape mortality data in stock assessment models is discussed in a paper by Breen and Cook (2002). A method of estimating escape mortality estimates for haddock are provided in Breen et al. (2007) and the report concludes that accounting for the discard and escape mortalities of haddock has an impact on fishing mortality patterns at age and leads to a lower estimate of F_{max} and a more “peaked” yield-per-recruit curve. Mesnil (1996) described a method of incorporating discard survival rates in Virtual Population Analyses which allows testing for the significance of discard survival effects despite the high levels of variability common in the discard estimates.

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Table 1. Summary of methodologies and results from discard and gear escape mortality studies of some Northeast groundfish species.

Common name of species	Gear type	Soak time/ tow duration	Depth Range sampled (m)	Mesh/hook type and size (mm) Codend for trawls	Discard or gear escapement mortality study method and survival observation period	Study region	Study season	N fish sampled	Length range (cm) of fish tested	Survival (%) and experiment observation period	Factors associated with increased survival	Comments	Reference
Atlantic Cod	Bottom trawl	1 vs. 2 hrs	36-90	140	Seabed cages placed at catch depth (caged 24 hrs)	GOM	Summer and spring	summer, spring (259, 99)	Not provided but noted	13% in summer and 51% in spring at 24 hrs after capture	Cod (air temp. < 48° F, deck time < 17 min., tow time = 1 hr, humidity > 60%, catch weight < 200 kg, and fish length > 41 cm)	Factors associated with increased survival were	Robinson and Carr, 1993
American plaice								summer, spring (170, 114)	as "juveniles"	44% in summer and 66% in spring at 24 hrs after capture	Am. Plaice (air temp. > 50° F, and deck time < 15 min.)	significant at the 0.05 alpha level based on contingency tests	
Yellowtail flounder								summer,spring (0,144)		No summer data, 87% in spring at 24 hrs after capture	Yellowtail (no effects detected)		
Yellowtail flounder	Bottom trawl	0.33 hrs	Not provided	Not provided	Not provided	waters off Massachusetts	Spring	173	Not provided	three-year mean <= 80% after 15 min. exposure on deck three-year range (<= 74-89%)		represents upper limit of survival rate due to short tow duration and deck exposure time (fishery tows are 1-3 hrs and deck exposure times are 0.5-1 hr)	Robinson and Carr, 1993
Atlantic Halibut	Bottom trawl	2 hrs	83-292	Not provided	Tank on vessel then transferred to tank in lab (50 days) and qualitative fishery observer data	Scotian Shelf	Summer	226	29-57 vs 58-80	35% at > 48 hrs after capture	Short handling time, larger fish size, and low total catch weight	provides % survival for various tow durations total catches, handling times, and fish lengths (mortality after 48 hrs may have been due to tank conditions)	Neilson et al., 1989
Atlantic Halibut	Longline		210-300	16/0 circle hooks		Scotian Shelf	Summer	31	62-80	77% at > 48 hrs after capture	Only fish length was tested and was NS		Neilson et al., 1989

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Winter flounder	Towed codend simulation	0.5 hrs	Not applicable	120 mm and 126 mm square and diamond	Gear escape mortality study	Narragansett Bay (winter flounder)	Not provided	WFL square = 58	Winter fl. mean = 16-18	WFL square = 95-100% at 10 days after codend escape	None provided	% survival of escapees may be overestimated	DeAlteris and Reifsteck, 1993
Atlantic Cod	apparatus in tank				Cages on seabed (10 days)	CC Bay (cod)		WFL diamond = 48	Cod mean = 41-44	WFL diamond = 85-96% at 10 days after codend escape		because each tow simulation involved only one fish	
								Cod square = 34		Cod square = 100% at 10 days after codend escape			
								Cod diamond = 41		Cod diamond = 100% at 10 days after codend escape			
American plaice	Bottom trawl	0.5 hrs	Not provided	38 mm diamond liner	Tank (>= 50 min.)	SW Gulf of St. Lawrence	Fall	149	10-19	40%, 27%, 12%, 0, and 0 for 5, 10, 15, 30, and 45 min. on deck	Larger fish size		Powles, 1969
									20-29	78%, 98%, 30%, 5%, and 0 for 5, 10, 15, 30, and 45 min. on deck			
Pollock	Bottom trawl (shrimp)	Commercial tow	Depth range of	44 mm diamond	Tank on vessel (1-2 hrs. after deck exposure times experienced in	GOM	Winter and spring	23	14-16	30% after 1-3 hrs	Short tow duration	Most tows conducted with Nordmore grates	Ross and Hokenson, 1997
American plaice		duration (mostly 2-3 hrs)	commercial fishery		the fishery: 15, 30, 45, 60, and 75 min.)			82	11-29	51% after 1-3 hrs	Short handling time, air temp., and larger fish size	All survival percentages include avian predation following release	
Witch flounder			max. = 110					27	9-28	52% after 1-3 hrs	Short handling time, air temp., and larger fish size	Survival rates are likely lower because	
Winter flounder								34	13-22	89% after 1-3 hrs		the survival observation period very short (max. = 3 hrs)	

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Atlantic Cod	Longline	Not provided	55	11/0 circle hooks	Tagged then transferred to tanks followed by cages on the seabed (caged 72 hrs)	SNE	Fall	630	sublegal size range (< 49)	mean = 31% (dehooked mechanically) after 72 hrs (range = 22-47%) mean = 45% (dehooked by hand) after 72 hrs (range = 38-63%) mechanically dehooked fish < 39 cm (11%) and fish >=38 cm (25%), N=157 50% avian predation post-release (N=81 and observation period < 3 min.)	Hand dehooking procedure (currently only mechanical Dehooking used), no jaw injury, and fish size >= 38 cm TL	Atlantic mackerel and *Illex* used as bait Mechanical dehooking = "crucifer"	Milliken et al., 1999
Haddock	Bottom trawl	Not provided	Not provided	70 mm diamond, dbl twine	Gear escape mortality study Escapees transferred from 35 mm codend cover to seabed cages by divers (60 days)	off coast of Scotland	Summer	699	16-32 (ages 0-3)	48-67% at 60 days after codend escape	Fish size > 24 cm, NS relationship between survival and increasing mesh size for the mesh size range tested	Concluded that unaccounted mortality of escapees is likely to be as important as discard mortality	Sangster et al., 1996
				90 mm diamond, dbl twine				2,055	17-38	79-82% % at 60 days after codend escape			
				100 mm diamond, dbl twine				1,506	16-36	73-83% % at 60 days after codend escape			
				110 mm diamond, dbl twine				1,772	15-35	85-89% % at 60 days after codend escape s			
Atlantic Cod	Bottom trawl	0.1 hrs	30-60	135 mm diamond	Cages attached to codend via small mesh cover then cages placed at 20 m (12-16 days in cages)	off coast of Norway	Summer	150-1,000	20-50	100% at 12-16 days after codend escape	None provided	Death occurred within first five days Dead fish counted via underwater camera so no length data Possible underestimate of survival because some mortality of small fish was attributable to caging methodology	Soldal et al., 1993
Haddock								150-1,000	20-50	>= 90% at 12-16 days after codend escape			

Common name of species	Gear type	Soak time/ tow duration	Depth Range sampled (m)	Mesh/hook type and size (mm) Codend for trawls	Discard or gear escapement mortality study method and survival observation period	Study region	Study season	N fish sampled	Length range (cm) of fish tested	Survival (%) and experiment observation period	Factors associated with increased survival	Comments	Reference
Atlantic Cod	Bottom trawl	1 vs. 3 hrs	35-92	135 mm diamond	Tagged then 10 min. in tubs (dry, submerged or sprayed) then placed in seabed cages at tow depth (caged 72 hrs)	GOM	Summer	272	Not provided but noted as "juveniles"	0-25% after 72 hrs for all treatments	Larger fish size (35-49 cm)		Carr et al., 1995
American plaice								316		35-37% (1 hr tows) and 17-29% (3 hr tows) after 72 hrs	Shorter tow duration (= 1 hr) and larger fish size (25-36 cm)		
Yellowtail flounder								570		75-89% (1 hr tows) and 66-69% (3 hr tows) after 72 hrs	Shorter tow duration (= 1 hr)		
Atlantic Cod	Bottom trawl	1 vs. 3 hrs	35-92	135 mm diamond with 51mm diamond, hooped cover	Gear escape mortality study Escapees caged in floating codend cover (caged 72 hrs)	GOM	Summer	Yr 1, Yr 2 (47, 25)		Yr 1 = 94% and Yr 2 = 96% at 72 hrs after codend escape			Carr et al., 1995
American plaice								(480, 568)		Yr 1 = 39% and Yr 2 = 41% at 72 hrs after codend escape			
Yellowtail flounder								(501, 236)		Yr 1 = 68% and Yr 2 = 90% at 72 hrs after codend escape			
Haddock	Pelagic longline	Not specified	50-70	Mustad wide gap	Shallow holding pens (11 days)	Northern Norway	Summer	Control: 46 Mechanical: 159	Mean = 50	Control: 91% after 11 days Mechanically dehooked: 61% after 11 days Dehooked by gaff: 47% after 11 days	Dehooking method	Gear similar to demersal longling but suspended in water column Mechanical dehooking = "crucifer", manual baiting and setting	Huse and Soldal, 2002
American plaice	Commercial beam trawl RV otter trawl	0.25-2 hrs	25-30 20-30	80-90 mm (shape not specified)	Tank on vessel (84 hrs)	North Sea	Winter, spring, fall	17-270	20-30	2.1-47.9% after 84 hours 0-54% after 84 hours	Water temperature, gear		Van Beek et al., 1990
Atlantic Cod	Bottom trawl	Commerical tow duration with low and high intensity	45-90	135 mm (shape not specified)	Gear escape mortality study Detachable codend cover/cage assembly (caged 6 days)	Barents Sea off coast of Norway	Spring	1,369	22-94 (mean = 45)	99.7% at 6 days after codend escape			Ingolfsson et al. 2007
Pollock								570	26-68 (mean = 42)	98.4% at 6 days after codend escape			
Haddock								12,571	12-61 (mean= 35)		Larger fish size	Cage depth negatively affected haddock survival	

Common name of species	Gear type	Soak time/ tow duration	Depth Range sampled (m)	Mesh/hook type and size (mm) Codend for trawls	Discard or gear escapement mortality study method and survival observation period	Study region	Study season	N fish sampled	Length range (cm) of fish tested	Survival (%) and experiment observation period	Factors associated with increased survival	Comments	Reference
Atlantic Cod	Automatic jigging machines		19-53 75-122	No. 12	Cages suspended at 5-9 m (caged 9days)	N. coast of Iceland	Summer	Each depth range N = 50 x 2 experiments	36-55	Mean = 57% after 9 days (shallow = 68%, deep = 46%)	Capture depth, size and type of injury at capture	Most deaths during first day; used rubber bait	Palsson et al. 2003
Atlantic Cod	Longline	1-4 hrs	36, 55, and 73	12/0 circle hooks	From tank on vessel to cages placed at depth of catch (caged 72 hrs)	Not provided	Spring, summer, fall, winter	3,764 (min. 150 per depth treatment per season)	< 56 (sublegal)	Mean = 64% and range = 31-81% after 72 hrs for mechanically dehooked fish	Lower capture temperatures (< 9.4° C) and shallower depths (36 m vs 55 and 73 m)	Bait was either clams or squid Jigged fish considered as controls but only healthy fish were selected	Rudolph et al. 2006

Table 2. Summary of discard survival rates and codend escapement survival rates for some Northeast groundfish species.

Common name of species	Gear type	Survival (%) and experiment observation period
Atlantic cod	Bottom trawl	13-51% at 24 hrs after capture
		0-25% after 72 hrs
	Bottom trawl	100% at 10 days after codend escape
		94-96% at 72 hrs after codend escape
		99.7% at 6 days after codend escape
		100% at 12-16 days after codend escape
	Automatic jigging machines	Mean = 57% after 9 days
	Longline	Mean = 64% at 72 hrs after capture (range = 31-81%)
		Mean = 31% at 72 hrs after capture (range = 22-47%)
American plaice	Bottom trawl	0 after 45 min. on deck
		44-66% at 24 hrs after capture
		17-37% after 72 hrs
	Shrimp trawl	51% after 1-3 hrs
	Beam trawl	0-54% after 84 hours
	Bottom trawl	39-41% at 72 hrs after codend escape
Witch flounder	Shrimp trawl	52% after 1-3 hrs
Yellowtail flounder	Bottom trawl	87% at 24 hrs after capture
		mean <= 80% after 15 min.on deck (range= 74-89%)
		66-89% after 72 hrs
	Bottom trawl	68-90% at 72 hrs after codend escape
Winter flounder	Shrimp trawl	89% after 1-3 hrs
	Bottom trawl	85-100% at 10 days after codend escape

Table 2. (cont.)

Common name of species	Gear type	Survival (%) and experiment observation period
Haddock	Bottom trawl	48-89% at 60 days after codend escape
		>= 90% at 12-16 days after codend escape
	Pelagic Longline	47-61% after 11 days
Pollock	Bottom trawl	98.4% at 6 days after codend escape
	Shrimp trawl	30% after 1-3 hrs
Atlantic Halibut	Bottom trawl	35% at > 48 hrs after capture
	Longline	77% at > 48 hrs after capture